SEE Bulletin
Developing Tomorrow's Space Technologies Today
NASA's Space Environments and Effects Program Summer 1999 Issue

MSFC's Engineering Technology Development Office (ETDO)

by Billy Kauffman

In May 1999, it became official. NASA's Marshall Space Flight Center survived its first "major" reorganization in 25 years. Many hours of preparation were exhausted to provide Marshall a renewed focus to its customers. Due to the SEE Program Office residing at Marshall, the office has been transferred to a new organization along with expanded responsibilities to Marshall's newly formed Engineering Directorate technology developments. The new office in which the SEE Program now resides is called the Engineering Technology Development Office (ETDO). External SEE Program participants will not see any changes how the SEE Program performs business. The SEE Program will continue to strive as hard as it can to be a NASA program as in the past. However transparent to external participants, this reorganization will have a positive effect on the SEE Office internal to Marshall for which we should become more efficient in responding to requests. The ETDO is a newly formed Engineering Directorate (ED) staff office that will:

· Provide an ED interface to product line directorates and other MSFC programs to establish awareness of ED technological capabilities, plans and other product line needs and activities

· Establish and implement an ED Technology Development Plan and manage a crosscutting ED technology development budget

· Provide a focused ED interface for collaboration with other government agencies

· Provide a focussed ED interface to promote ED technology development activities

The ETDO will not only concentrate on SEE technologies for Marshall's Engineering Directorate, it will also include materials processes and manufacturing, avionics, structures, mechanics, thermal as well as engineering systems.

NASA's Administrator has expressed a desire for the Marshall Space Flight Center to move toward a research and technology center. To support this direction, the new Engineering Director, Mr. Jim Kennedy, is leading the Engineering Directorate to meet the challenge of moving towards increased technology development to support future missions. A structured and pro-active technology development program has been established and in place to keep the MSFC Engineering Directorate on the leading edge of technology advances in support of the MSFC product lines.

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If you have moved, changed E-mail addresses, etc., please inform the SEE Program Coordination Office so we may update our database. You may do this by E-mailing Billy Kauffman:

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Interactive Spacecraft Charging Handbook

(Referenced from AIAA-99-4594, Interactive Spacecraft Charging Handbook With Integrated, Updated Spacecraft Charging Models, I. Katz, V. Davis, M. Mandell, B. Gardner, and J. Hilton)

by Jody Minor

The SEE Program is pleased to announce that the new Interactive Spacecraft Charging Handbook is now available for download from the SEE website. The Handbook contains integrated, updated spacecraft charging models, updated design guidelines, and new deep dielectric charging models.

There are two main sections of the Handbook: Guidelines and Tools. The Tools option allows users to investigate the charging of their spacecraft. The two environment tools, Geosynchronous and Trapped Radiation, allow users to specify and compare charged particles fluxes of different environments. The Materials Properties tool allows users to specify the relevant materials for spacecraft surface materials. It also permits the user to adjust properties (such as the secondary and backscattered yields) until they agree with measured data. The three surface charging tools, Single Materials, Multi-Materials, and Three-Dimensional, are used to examine surface charging of a spacecraft (although not all surface charging tools are available at this time). The Internal Charging tool is used to investigate the electric field due to deposition of high energy (MeV) electrons within circuit boards, cable insulation, and other dielectrics.

The Guidelines option is a text document that provides guidance to the spacecraft design engineer. The Guidelines consist of four sections: Spacecraft Charging Overview, Interactions Modeling Techniques, Spacecraft Design Guidelines, and Control and Monitoring Techniques. The Guidelines are access by clicking on the word “Guidelines” in the table of contents to the left of the web page. Within the guidelines, the chapters are navigated using the bar at the bottom of the page. The document can be printed using the browser’s print function.

Version 1.01 is the first deliverable of a three-year contract. During the second and third years, more capabilities will be added to the Handbook as they are developed, such as three-dimensional surface charging. The Interactive Spacecraft Charging Handbook is being developed for the SEE Program by Maxwell Technologies and now is available at http://see.msfc.nasa.gov. For more information, please contact Jody Minor at jody.minor@msfc.nasa.gov.

The Electromagnetic Effects (EME) TWG Technology Roadmap Workshop that had been planned for the summer of 1999 has been postponed until further notice. A new meeting date will be set and will be advertised in the Bulletin and SEE website. For further information contact Jody Minor at 256-544-4041.

Model for Emission of Solar Protons (ESP) Cumulative and Worst Case Event Fluences

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The effects that solar proton events have on microelectronics and solar arrays are important considerations for spacecraft in geostationary and polar orbits and for interplanetary missions. Designers of spacecraft and mission planners are required to assess the performance of microelectronic systems under a variety of conditions. A number of useful approaches exist for predicting information about solar proton event fluences and, to a lesser extent, peak fluxes. This includes the cumulative fluence over the course of a mission, the fluence of a worst case event during a mission, the frequency distribution of event fluences, and the frequency distribution of large peak fluxes. Information about single events supplements the long-term information, and it is useful for assessing worst case scenarios.

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Two models commonly used for cumulative fluence estimates are the SOLPRO model based on King's analysis of spacecraft measurements from solar cycle 20 data and a model from JPL which was based on ground data from solar cycle 19 and spacecraft measurements from solar cycles 20 and 21. Because the SOLPRO model was based on a solar cycle in which one solar proton event dominated the total fluence for that solar cycle (the August 1972 event), the model predicts the number of extremely large events expected for a given mission length and confidence level. Using additional data from solar cycles 19 and 21, the Feynman team later showed that the severity of solar proton events actually forms a continuum between very small events and the "anomalously" large events of the magnitude of the August 1972 event. Spacecraft measurements from solar cycle 22 gave further evidence that extremely large events are not an anomalous occurrence with six events occurring that had fluence levels > 1.0 x 10^9 *protons-cm^{-2} at energies greater than 10 MeV.*

The SOLPRO and JPL models have been very useful for predicting event fluences for long-term degradation but do have limitations due to the incomplete nature of the data sets upon which they were based. The first limitation is the energy range. The SOLPRO model covers energies > 10 to > 100 MeV and the JPL model covers energies > 1 MeV to > 60 MeV. The fluence levels below 10 MeV are desirable for accurate predictions of solar cell degradations, whereas, the higher energy particles, with their greater ability to penetrate shielding, are important to consider for total dose degradation of system electronics. Clearly, a model that has adequate energy range for both applications is needed. Also, note that neither model includes all of the solar cycles for which data are available. This is very important because the three solar cycles with high quality space data are dissimilar from one another. Cycle 20 had one extremely large[1] solar proton event that accounted for most of the accumulated fluence, cycle 21 had no extremely large proton events, and solar cycle 22 had six extremely large events with three occurring within a one month period (September-October 1989). Another limitation of these two models is that they do not describe the worst case solar proton event during a mission, the frequency distribution of large events, or the frequency distribution of large peak fluxes.

Naval Research Laboratory (NRL) and NASA/Goddard Space Flight Center, under the sponsorship of NASA's Space Environment and Effects (SEE) program and NRL, have developed a new model for predicting cumulative solar proton fluences and worst case solar proton events as functions of mission duration and user confidence level. Peak flux distributions will be added to the model at a later date. This model is called the Emission of Solar Protons (ESP) model.

The ESP model predicts integral omnidirectional solar proton fluences for interplanetary space at 1 astronomical unit (AU). The model will be expanded to include attenuation by the magnetosphere for geocentric orbits and for distances outside of the magnetosphere other than 1 AU. The energy range of the statistical model is > 1 to > 100 MeV. Unfortunately, the satellite instrument measurements for energies greater than 100 MeV are not sufficient for a true statistical model. Therefore, for energies from 100 to 300 MeV, an empirical approach was taken based on spacecraft measurements for solar cycle 22.

The ESP model is based on satellite measurements from 1963 through 1996, covering solar cycles 20, 21, and 22. Several previous analyses of solar proton satellite data were reviewed for this study, including those by King, Armstrong, Goswami, Feynman, and Shea and Smart. The statistical model was developed using a new approach for analyzing the database of spacecraft measurements. The approach recognizes that the nature of the data set is incomplete and that solar events are similar in their pattern of occurrence to earthquakes.

The model and users guide will be available for distribution in early August 1999. Please visit the SEE Program website at http://see.msfc.nasa.gov for instructions on how to obtain a copy of each. A bound copy of the users guide should be available around October 1999.

[1] Extremely large events are defined as those with total fluence levels exceeding 1.0 x 10^9 protons-cm^{-2} at energies greater than 10 MeV.

Coming in Fall 1999 Issue...

- **Cross Enterprise Technology Development Program**
- **AIAA Highlights**
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http://see.msfc.nasa.gov/

Recent Website Additions:

- Material Selection Guidelines to Limit Atomic Oxygen Effects on Spacecraft Surfaces, NASA/TP-1999-209260: *http://see.msfc.nasa.gov/see/mp/mppub.html*
- Multilayer Insulation Material Guidelines, NASA/TP-1999-209263: *http://see.msfc.nasa.gov/see/mp/mppub.html*
- Development of Tailorable Electrically Conductive Thermal Control Material Systems, NASA/CR-1998-208474: *http://see.msfc.nasa.gov/see/mp/mppub.html*
- Spread Spectrum Received Electromagnetic Interference (EMI) Test Guide, NASA/CR-1998-208535: *http://see.msfc.nasa.gov/see/ee/eepub.html*
- 1999 Leonid Fluence Calculator: *http://see.msfc.nasa.gov/see/models/lsfc/1999/lfc1999.htm*
- Interfactive Spacecraft Charging Handbook: *http://see.msfc.nasa.gov/see/ee/model_charging.html*

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